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Transit Times of the Spots on Jupiter. By W. F. Denning, Esq.

During the past autumn and winter a number of observations of *Jupiter* were made here* for the purpose of estimating the times of transit of the Red Spot and of other conspicuous objects on his disk. The telescope was a Browning-With Reflector of 10 inches' aperture, power 300, and a Barlow lens, which increased it to 450, was invariably used. The results are given in a tabulated form for each object separately.

Transits of the Great Red Spot.

		Preceding End.	Middle.	Following End.	Middle of Spot. Precedes first Meridian.
		h m	h m	h m	m
1880, Sept.	27	10 26	10 51	11 15	54·9
	30	7 56	8 16	8 39	57·4
Oct.	11	11 47	12 16	12 46	52·1
	14	9 17	9 46	10 12	49·7
	18	12 39	13 5	13 35	44·5
	23	11 44	12 12	12 41	42·1
	24	7 34	7 59	8 26	45·9
	29	6 40	7 8	7 36	41·7
Nov.	2	10 0	10 26	10 57	37·8
	3	5 44	6 12		42·7
	4	11 36	12 4	12 38	36·9
	8	4 50	5 21	5 53	38·8
	9	10 41	11 12	11 39	34·1
	14		10 20	10 45	31·4
	17	7 17	7 44	8 12	35·6
	19	8 59	9 23	9 52	33·9
	20	4 48	5 14	5 43	33·8
	21	10 38	11 4	11 32	30·3
	25		4 25	4 49	28·6
	27	5 34	6 0	6 29	31·0
	28	11 24	11 49		28·5
	29	7 11	7 40	8 9	28·4
Dec.	2	4 38	5 8	5 37	28·9
	10	11 20	11 47		20·2

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* An abstract of my earlier observations appears in the *Monthly Notices* for November, 1880, pp. 44–46.

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		Preceding End.	Middle.	Following End.	Middle of Spot. Precedes first Meridian.
		h m	h m	h m	m
1880, Dec.	15	10 30	10 56	11 22	17·5
	20	9 38	10 4	10 33	16·0
	25	8 40	9 12	9 39	14·6
	28	6 15	6 40	7 7	15·5
	30	7 50	8 21	8 50	12·4
	31		4 11	4 39	13·5
1881, Jan.	6	8 40	9 7	9 33	11·1
	7	4 31	4 57	5 25	12·3
	12		4 5	4 32	11·3
	13	9 27			
	14	5 17	5 44	6 13	10·3
	16	6 54	7 23	7 52	9·2
	31		4 49	5 18	4·9
March	17	6 36	7 1		+ 3·5

Average duration of transit = 55·5 min. (28 transits).

On December 2, 1880, the following end of the spot had the same longitude as the assumed first meridian of *Jupiter* computed by Mr. Marth[*] from the rotation period of spots seen in 1834–5 and 1862—namely, $9^{h}\ 55^{m}\ 27^{s}{\cdot}08$, which corresponds to a daily rate of $870^{\circ}{\cdot}600$. The red spot moves slower than this, its period being as nearly as possible 7 seconds greater than that adopted in calculating the passages of the first meridian. Thus during the period embraced by the above observations the comparative times of transit of the spot and of the assumed first meridian shows a considerable difference, for while on Sept. 27, 1880, the middle of the spot preceded this element by 55 minutes, it had so far lost ground by March 17, 1881, as to follow it by 3½ minutes; the difference amounting to nearly an hour in the 171 days. The centre of the spot must have had coincident longitude with the assumed first meridian on about February 26, but no observations could be made at that epoch owing to cloudy weather.

In October I frequently noticed a dusky elongated marking or short streak south preceding the red spot about 1½ hour. It crossed the central meridian of *Jupiter* at about $10^{h}\ 35^{m}$ on Oct. 11 and at the end of that month I began to note it particularly. The following are the times when the centre or following end was estimated as central:—

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[*] See *English Mechanic*, Nos. 807, 814, and 821.

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Transits of Dusky Streak s.p. Red Spot.

	Middle.	Following End.	Middle Precedes ♃'s First Meridian.	Precedes Red Spot.
	h m	h m	h m	h m
1880, Oct. 11	10 35?			1 41?
31	7 15		2 11·8	
Nov. 2	8 48	8 59	2 15 8	1 38
4	10 28	10 37	2 12·9	1 36
8	13 41	13 53	2 14·2	
12	6 59		2 15·2	
17	6 3	6 15	2 16·6	1 41
22	5 7		2 18·2	
24	6 46		2 16·6	
26	8 25		2 15·0	
27	4 16		2 15·0	1 44
28	10 1	10 16	2 16·5	1 48
29	5 48	6 5	2 20·4	1 52
Dec. 18		6 38		
20	7 56	8 12	2 24·0	2 8
21		4 11		
25	6 59	7 14	2 27·6	2 13
28		4 44		
30	6 3	6 20	2 30·4	2 18
1881, Jan. 6	6 45	6 59	2 33·1	2 22
8	8 22	8 40	2 34·0	
13	7 24	7 43	2 39·1	
16	4 52	5 8	2 40·2	2 31
Feb. 16		5 35		

The first observation on Oct. 11 is doubtful; the time is probably too early.

Average duration of transit (computed from 13 observed passages of the middle and following end of the spot) 29·4 min., so that the spot was slightly more than half the length of the red spot. When definition was poor it appeared more diffused and longer than when the image was sharp and the spot seen in a favourable and true aspect. Mr. Barnard, at Nashville, Tennessee, had figured this spot (*English Mechanic*, No. 804) as early as July 25, 1880, when it was apparently attached to the preceding end of the red spot; but it had subsequently been rotating in shorter intervals than that object, and its swifter motion had caused its gradual drift westwards. In the above table I have compared the period as observed here by which

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it preceded *Jupiter's* first meridian and the red spot, and it will be noticed that while on November 2 and 4 it came to transit slightly more than $1\frac{1}{2}$ hour before the red spot, the interval had increased to $2\frac{1}{2}$ hours by January 16. In fine, its period of rotation was performed in $17\frac{1}{2}$ seconds less time than the red spot,* and this accords exactly with similar observations by Mr. Barnard, who has been watching another object of the same character in the southern hemisphere of *Jupiter*, and deduced a period of $9^h\ 55^m\ 16^s{\cdot}176$.† There were a number of these dusky short streaks visible in this region of the planet during his recent opposition; they were markedly persistent, and, though preserving the same positions relatively to each other, they all moved quicker than the red spot.

On September 18, 1880, I detected a very brilliant spot just south of the Jovian equator, and the same object was observed on many subsequent occasions. After the middle of October I obtained as many of its transits as possible, for it gave the most unmistakeable signs of great proper motion. The same feature was frequently observed by Schmidt at Athens in October and November 1880 (see *Astronomische Nachrichten*, No. 2353), and he has deduced its rotation period as $9^h\ 50^m$, or $5^m\ 34^s$ less than the red spot.

The following are the transits observed at Bristol:—

Bright Spot South of Equator.

	h	m		h	m
1880, Sept. 18	11	50?	1880, Nov. 29	5	27
Oct. 20	11	38	Dec. 3	7	54
30	7	28	10	7	14
Nov. 2	14	15	12	8	27
3	9	47	15	5	16
4	5	25	21	8	49
8	7	48	23	10	4
17	8	14	28	7	59
19	9	23	1881, Jan. 6	8	27
20	5	2	7	4	5
21	10	41	13	7	37
26	8	44	16	4	28
27	4	19	Feb. 23	7	5?
28	9	51			

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* See *English Mechanic*, No. 824, Jan. 7, 1881, p. 421.

† The small spot referred to was mentioned in *Monthly Notices*, Nov. 1880, p. 46, as "maintaining a permanent position with reference to the red spot," but this was stated before my prolonged observations had enabled me to detect the differences here referred to.

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I gave the period as 9h 50m 5s in *English Mechanic*, No. 818, Nov. 26, p. 277,* and this agrees with that derived by Mr. Marth (*ibid.* No. 830, Feb. 18, p. 564) from more comprehensive observations during the interval Sept. 18, 1880–Jan. 13, 1881, by Schmidt, Corder, Dennett, McCance, Barnard, and myself, including 55 transits which indicated the daily rate of rotation as 878°·48, and the corresponding period 9h 50m 6s·6. This remarkable spot was noticed by many observers independently. It came to conjunction with the red spot on Nov. 19 and Jan. 3, but on the latter date clouds prevented observation. After Jan. 16, a prolonged period of overcast skies prevented a continuance of the observations, and the spot was not identified afterwards, though on Feb. 23, at 7h 5m I saw a bright object nearly in the calculated place, and it was watched in transit. Its absolute identity with the spot so frequently seen during Oct., Nov., and Dec., could not, however, be inferred, and there is also some doubt attached to the original observation on Sept. 18, owing to the long intervening period between that date and the next observed transit on Oct. 20. There were several of these bright spots presented on *Jupiter* in very nearly the same latitude, so that, unless the observations were made at short intervals, there was considerable difficulty in distinguishing them apart. But, fortunately, in the case of the brilliant object I have been particularly alluding to, it was of special type, being considerably brighter and more conspicuous than any others of its class, and situated slightly further south. It was occasionally noted as extremely faint, while at other times it seemed very distinct and comparable to the bright disk of a satellite on the limb of *Jupiter*, near the beginning or end of a transit. Generally, however, it was very distinct, and its rapid motion relatively to the red spot could be clearly traced on succeeding nights. It was preceded and followed closely by spots of similar character, though fainter, and intermittently visible, which showed the same swift movement westwards; indeed, the mass of detail manifested on the equator appeared to be influenced by the same rapid current relatively to the red spot, and by some singular variations in form. Many large white patches made their appearance, but soon became diffused along the light N. border of the great South belt, and there were dusky strips intervening which also participated in the remarkable motion and variations referred to.

The small dark spots visible in a belt N. of the great equatorial zone, which I referred to in my paper in *Monthly Notices* for Nov. 1880, pp. 44–46, were re-observed as frequently as possible, but their variations of position and form were so great as to render it almost impossible to trace the identical objects at their succeeding apparitions. The two chief spots of the cluster were, however, followed as long as practicable, and the following transits observed here:—

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* See also *Monthly Notices* for Nov. 1880, p. 45.

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		I.	II.
		h m	h m
1880, Oct.	29	7 31	7 54
Nov.	2	9 31	9 52
	3	5 5	5 31
	4	10 41	11 4
	8	12 37	13 3
	23	5 14	5 39
	29		8 44
1880, Dec.	2	4 55	5 39
	15		6 48
	20		4 11
1881, Jan.	6	7 30	8 11
	7		3 50
	8	8 46	

These spots travelled with greater velocity than any other of the markings. The approximate period was 9^h 48^m, but the motion was not uniform. They were observed to overtake and pass the white spot on the equator early in January.

Towards the middle of January they apparently formed a complete girdle around the planet, but the spots were evidently losing their distinctive character. What had formerly been a single belt N. of the great equatorial zone was now a double belt; the one nearest the equator was the most conspicuous, and had evidently been formed by the dispersion of the materials of the spots, which had been going on under the eyes of observers during the three preceding months.